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ABSTRACT

A study involving 441 students enrolled in pre-calculus mathematics courses at Black Hawk College, Illinois, during Spring 1981 was conducted to measure the correlation between the level of students' math anxiety and four independent variables: sex, age, math background (as measured by the highest level of math course previously completed), and the last grade received in a mathematics course. The study involved: (1) the administration of the Mathematics Anxiety Rating Scale (MARS) to the students to measure their math anxiety on an increasing scale of 98 to 490; (2) the administration of a second instrument to determine the four independent variable characteristics; and (3) a statistical analysis of the data to determine those correlations that were significant at the .05 level. The study revealed that age was the only variable that was not statistically significant in the determination of the level of math anxiety. Females were significantly more likely to have higher levels of math anxiety than males. Students who had completed only a general mathematics course were more likely to have higher levels of math anxiety than students who had completed more difficult courses, and students receiving a "C" in their previous math courses were more likely to have higher levels of math anxiety than students who had received higher grades. The study report reviews relevant literature and details statistical findings. (JP)

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A Study of the Relationship Between
Level of Mathematics Anxiety and Sex,
Age, Mathematical Background, and Previous
Success in Mathematics

A Research Study

Presented to

Dr. Norman L. Krong

Department of Educational Administration

Western Illinois University

In Partial Fulfillment

of the Requirements for

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by

Elyse L. Calvert

February 1981

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CHAPTER I

INTRODUCTION

In mathematics teaching and research today, a recurrent problem has been that of the mathematics anxiety felt by mathematics students and by those contemplating the study of mathematics. Early in the 1960's a few scattered studies appeared which attempted to explore the extent that number anxiety and attitudes toward mathematics study were related to success in mathematics (1, 8, 7).

But it took the feminist movement in the 1970's and the publications of such active researchers as Sells, Fennema, and Tobias to bring the serious problem of mathematics anxiety and mathematics avoidance to the attention of educators nationally. At that time, despite the fact that concern with generally lower achievement in mathematics among the high school graduates was leading to the establishment of more and more remedial mathematics courses in colleges across the country, few educators seemed willing to focus on the mental blocks and attitudes that were keeping large numbers of able students away from mathematics study at the college level.

From 1975 to the present, this trend has changed and an intensive movement aimed at understanding and countering mathematics avoidance has sprung up. The federal government has contributed by funding important new research on sex-related and minority-related difference in mathematics achievement. Centers for countering the problem of mathematics avoidance have appeared. Colleges in California, such as Mills College in Oakland,

and in the East, such as Wellesley University, have initiated clinics and workshops aimed at acquainting high school students, their parents, and their teachers with the high cost in human potential occurring when students avoid the study of mathematics.

A major outcome of this over-all activity has been the realization that the entire nature of mathematics avoidance must be examined. What happens in the early school years to destroy students' confidence in their mathematical abilities? How is it possible that students exhibiting a high level of ability in other areas show a complete lack of self-confidence when the course to be attempted involves mathematics? Most importantly, are there steps that can be taken among adults and college-age students which can reverse the patterns of mathematics avoidance and anxiety?

These trends and concerns assume special importance when the present rapid growth of new occupations is considered, especially occupations requiring a background in mathematics. Today more than 80 per cent of the career choices open to college freshmen require a knowledge of mathematics. One researcher (21, p. 69) found that three-fourths of the job recruiters at the University of Maryland in 1977 would not interview seniors who did not have at least one semester of college calculus on their transcript. The present rapid growth of computer technology is an outstanding example of the increasing need for students able and willing to undertake the study of mathematics at the college level.

Statement of the Problem

One of the major blocks preventing a student from enrolling in mathe-

matics courses is the mathematics anxiety experienced by the student. This study was developed in response to a critical need for the level of that anxiety to be measured and charted. In addition, the exploration of possible correlation of the intensity of that mathematical anxiety with several key variables was considered worth investigating.

The Hypotheses

1. The first hypothesis

There is no significant difference between the level of mathematics anxiety experienced by males and the level of mathematics anxiety experienced by females, at the .05 level, as tested by use of the MARS Test.

2. The second hypothesis

There is no significant difference, at the .05 level, among the levels of mathematics anxiety experienced by persons of different ages.

3. The third hypothesis

There is no significant difference, at the .05 level, between the levels of mathematics anxiety experienced by persons with different backgrounds of mathematical experience (shown by the highest level of mathematics course previously completed).

4. The fourth hypothesis

There is no significant difference, at the .05 level, between the level of mathematics anxiety experienced by persons receiving different grades in their last completed mathematics courses.

Definition of Terms

Mathematical anxiety. A student who experiences fear of failure in a mathematics course, who actively avoids working with numbers, who cannot read mathematical terms with understanding, and who often states he could never succeed in mathematics, or that he has always hated it is afflicted with mathematics anxiety. Other symptoms include distrust of one's own ability to work out a mathematics problem, avoidance of courses requiring a mathematics background, and actual physical changes (trembling, perspiration, nausea) when forced to take part in a situation requiring computational skills or knowledge of mathematics. (Also known as mathophobia).

MARS test. The Mathematics Anxiety Rating Scale test, which is often abbreviated to MARS, is a 98-item self-rating scale which is administered to individuals or groups. The subject reads a specific item and checks the current level of anxiety he feels when faced with that situation. For example, one item reads, "Checking over your monthly bank statement," and another, "Watching a teacher work an algebraic equation on the blackboard." The subject checks one of five boxes after each item, indicating an anxiety level of not at all, a little, a fair amount, much, or very much.

Mathematics background. In this study mathematical experience will be measured by recording the highest level of mathematics course previously completed by each subject. This is a meaningful measure of past experiences because mathematics courses are sequential in nature. If a student has completed Algebra II, he must first have completed Algebra I. If he has completed Calculus I, he must first have successfully completed

Algebra I, Algebra II, college algebra, and trigonometry.

Importance of the Study

In the light of current emphasis on mathematically prepared students, a special burden falls on the two-year college mathematics department. With their open-door policy of accepting all high school graduates, the two-year colleges each semester see large numbers of students entering their doors, either fresh from high school or as older students seeking retraining and new careers. Such varied backgrounds inevitably produce a student body with infinite variations in previous mathematics study and with equally infinite variations in previous levels of success in mathematics.

Most schools, including Black Hawk College, have mathematics placement tests which help determine where each student should enter college level mathematics courses. These work fairly well, and, along with individual conferences, provide some guidance for placing students in the correct level of study.

However, almost none of these entering students across the country are given an assessment test to determine the level of mathematics anxiety each one carries within himself. Even though the phenomena of mathematics anxiety is beginning to be recognized by educators as an existing condition among mathematics students as well as within the general population (23, p. 74; 2, p. 297), not enough attention is being paid to seeking to establish the level of this fear as one of the bases for best advising the student concerning the correct starting point in mathematics study. In addition, such information about student attitudes toward mathematics

is not being actively sought nor utilized by instructors as they plan class work for each new semester.

Finally, not enough effort at using predictive measures has been made by mathematics departments and instructors as they attempt to deal with overcoming mathematics anxiety. If a typical profile of the student most likely to exhibit moderate to extreme fear of mathematics could be determined, the use of a profile check list, such as to sex, age, previous courses completed, and previous success in mathematics study, would be extremely useful to counselors and mathematics department advisors in general.

The present study does not pretend to be a final answer to predicting which students will have the most extreme level of mathematics anxiety. It is a starting point, however, in that it presents an in-depth study of all the entering mathematics students at one typical midwestern two-year college, up through the precalculus level of study. The correlation data may serve as a basis for planning further studies which would attempt to answer some of the questions of those researchers who are

turning their attention to the self-conditioning, the attitudes, the psychological mind-set, and the self-defeating behaviors that characterize persons who have given up on themselves in regard to math." (24, p. 2)

On a short range basis, the present study had value for the instructors in the mathematics department at Black Hawk College for the spring of 1981. With a careful assessment of the over 450 mathematics students beginning their mathematics study this semester to be available to the instructors, they could plan far better than ever before ways to teach

most effectively, according to the levels of mathematics anxiety which were known for each class section.

Delimitations

This study was limited to those 441 students out of the total enrollment at Black Hawk College, Spring semester, 1981, who had already enrolled in a mathematics class for that semester. Therefore, it does not represent a completely unbiased sampling of the entire student population. However, this method of selecting subjects was partially dictated by the ready accessibility of the group of subjects to the researcher.

This study was limited to the extent that the survey instrument used required the subjects to answer questions about how they felt and was thus dependent upon the subjects' desire and ability to reveal beliefs about themselves.

This study was limited by the dependency on the use of five other instructors in the department as well as the researcher to administer the MARS test to the subjects. To help insure uniform procedures, a common introductory statement was read by each administrator before the groups were asked to fill in the check lists. The use of other administrators was necessary to ensure that all the subjects would be tested within the first two days of the semester, before individual classroom instructors, textbooks, and teaching methods could have an effect on the levels of anxiety being measured.

This study was limited by the use of a self-perception instrument whose construct validity was tested on large samples of students at four-year universities but never previously tested on two-year college students only.

CHAPTER II

REVIEW OF THE LITERATURE

Identification of Mathematics Anxiety and Success Predictors

One of the earliest studies conducted to determine college students' reactions to number situations was completed in 1957 among 704 students in basic mathematics courses at Florida State University (8, p. 345). Both males and females were used in the study, and "number anxiety" as used by the researchers was defined by three scale items on the Taylor Manifest Anxiety Scale, one devised by researcher Janet Taylor in 1953. The three hypotheses formulated by Dreger and Aiken in this study were as follows:

1. Number Anxiety exists as a factor distinct from general anxiety, although it may accompany it.
2. Number Anxiety is not related to intelligence as measured by the Wechsler-Bellevue or ACE scales.
3. Persons with high Number Anxiety will tend to make lower scores in mathematics than others, even though intelligence between these two groups is not significantly different. (8, p. 345)

One interesting result was the authors' position that they found an over-all dimension that may be termed Number Anxiety which differed from general anxiety. They also determined that work was needed to identify exactly what Number Anxiety consisted of. Certainly since 1957 much research has been done in this general area. The researchers concluded that "all three of the proposed hypotheses were substantially supported by the research" (8, p. 350).

A few years later, in 1962, Cristantiello investigated the differ-

ences in the predictive validity of ACE Psychological Examination Quantitative (Q) scores among students grouped on the basis of their attitude toward mathematics. The hypothesis under investigation was that correlations for the predictor variable would be positive for subjects having more neutral attitudes toward mathematics than among those with the least neutral attitudes. Since the subjects chosen were 264 all-white male college sophomores, generalization on the basis of Crisantiello's findings might be difficult, but the study itself is of interest, though the researcher failed to identify the so-called 'standardized attitude scale' (7, p. 184) which he used to obtain a measure of the students' attitude toward mathematics.

Using this scale, the subjects were divided into three groups, namely, those with high positive attitudes towards mathematics, those with low positive attitudes, and a middle group. The hypothesis as originally stated seemed to be confirmed; that is, the ACE Q-score has a greater validity in predicting mathematics achievement for students with the most neutral attitudes (the middle group) toward the subject.

One year later Aiken conducted a similar study among 160 sophomores at an all-women's college in the southwest. He was following up on an earlier study by Dreger and Aiken, which had indicated that nonintellective factors had more influence on attitudes of females toward mathematics than on attitudes of males. The hypothesis of this later investigation was that attitudes toward mathematics are significantly related to general personality variables, and this tended to be confirmed by the study. A 20-item Revised Math Attitude Scale, which had been previously checked for reliability and validity, was administered to the subjects, as well

as three objectives tests of personality, which were the California Psychological Inventory, the Sixteen Factor Personality Questionnaire, and the Study of Values. Aikens' results indicated that

high scorers on the attitude scale, with mathematical ability statistically controlled, tend to be more socially and intellectually mature, more self-controlled, and place more value on theoretical matters than low scorers on the attitude scale. (1, p. 479)

Though one type of study not often found in this area of attitude toward mathematics was the longitudinal study, an exception was the study by Anttonen in 1969 examining the relationship between mathematics attitude and mathematics achievement extending over a 6-year period. A group of 607 fifth and sixth grade students were tested in 1960, and then were tested again in 1966 when they were in 11th and 12th grades. The researcher was examining the stability of mathematics attitudes over a 6-year period and attempting to relate mathematics attitude to mathematics achievement, considering both the entire group and also the two grades and the sexes separately. Anttonen was suitably cautious in reading firm conclusions but did find a low correlation between elementary mathematics attitude scores and both elementary and secondary mathematics achievement, indicating that it would be risky to predict either elementary or secondary mathematics achievement from a 5th-6th grade attitude measurement instrument alone. There was higher correlation between secondary attitude scores and secondary mathematics achievement, leading to the conclusion that at the high school level somewhat better predictions of mathematics achievement may be obtained from mathematics attitude alone.

Anttonen concluded with some interesting suggestions for future study

in the areas of student interviews for discovering mathematics attitudes, mathophobia exploration to attempt to foster more positive feelings, and attempts to overcome emotional blocks. A look at more recent research indicated that these areas were certainly explored by researchers in the next decade.

A thorough update on the research done on attitudes toward mathematics and other variables affecting the learning of mathematics was given by Aiken in 1976. Many of his conclusions and summarizing statements were based on doctoral dissertations not readily accessible. He found that in addition to the older Thurston-type and Likert-type instruments used to measure affective reactions to mathematics, a dozen or more new instruments had appeared for use at the elementary, secondary, and college levels (2, p. 295). A most promising and reliable measure of anxiety toward mathematics was the Mathematics Anxiety Rating Scale, sometimes called MARS, created by Richardson and Suinn. (See Appendix A). Studies tended to find that attitude toward mathematics was directly related to both actual and aspired marks in mathematics courses (2, p. 296).

In regard to sex differences in mathematics, it was found that girls' mathematics marks were more predictable from their attitudes than boys' marks. Aiken's conclusions are worth noting:

Sex and personality variables related to attitude toward and ability in mathematics continues to be a popular topic...in prediction studies involving a measure of attitude toward mathematics, separate analyses by sex should always be conducted...Finally, the promising beginnings on the treatment of mathophobia by behavior modification approaches should be refined and extended. (2, p. 303)

Sex Differences in Mathematics Anxiety and in Teacher Expectations

No area of mathematics research has received more attention in recent years than that of the relationship between mathematics ability and sex. As an outgrowth of this, many recent programs have been developed nationwide (such as the San Francisco Bay Area, Wesleyan University, University of Wisconsin-Madison, University of North Carolina-Wilmington, and the University of Maryland, University of Missouri-Kansas City, to name only a few) to treat the problems of mathematics anxiety, mathematics avoidance, and re-entry problems, all with the aim of furthering female participation in the study of mathematics. What caused this realization that women needed incentives and help in the area of mathematics? A look at recent research will provide the answers. Findings have shown that stereotyping on the basis of sex begins with birth and is later reinforced in schools, where textbooks, activities, and teachers' and parents' attitudes convey over and over the message that boys are good in mathematics but girls are not and should not worry about it (9, p. 5; 14, p. 2; 19, p. 196; 17, p. 162).

Sells found the pattern of avoidance of² mathematics study among women overwhelming in her initial key survey of entering freshmen at the University of California-Berkeley in 1972 (23, p. 39). Over 57 per cent of the entering males had taken four years of high school mathematics, compared to only 8 per cent of the females. This early research opened the doors to many similar surveys and studies of sex differences in mathematics.

In 1975 John Ernest, with the help of a team of ten graduate students, published a report called "Mathematics and Sex." This report summarized results of research begun in the fall 1973 during a freshmen

seminar on women in mathematics. The study centered about four areas: student attitudes toward mathematics in elementary and secondary school, attitudes of teachers, sex differences in high school mathematics training, and the situation at the university level at the University of California at Santa Barbara.

In a survey of 1324 elementary and secondary students, three questions were asked. The first concerned the subject most liked by the students. Strikingly, in terms of liking the subject, mathematics was the only subject in which no sex differences were exhibited (9, p. 3). This pattern of no sex differences in liking mathematics continued through the grades, although in high school both boys and girls found mathematics less appealing.

The second question Ernest asked concerned who helped the subjects most with their school work at home. For both boys and girls, from sixth grade through high school the father was the one who was consulted for help with mathematics. In answering the third question, about who does best, boys or girls, in mathematics, a strange finding appeared. Through the lower grades, girls said that girls did best in all subjects and boys said that boys did best in all subjects. But among high school students, 32 per cent of all students surveyed in grades 9 through 12 felt that boys did better in mathematics compared to 16 per cent who felt girls did better. Ernest felt that the responses to questions two and three indicated clearly that there was an attitude of sexual stereotyping in regard to mathematics ability showing up in high school years.

The second part of Ernest's research dealt with teacher attitudes

within a small sample (27 in all) of elementary and high school teachers. Forty-one per cent of those questioned felt that boys did better in mathematics and not one felt that girls did better (9, p. 6). Ernest theorized that such feelings on the part of teachers would certainly be detrimental to female students' attitudes toward mathematics as they proceeded through their years of schooling.

In the last of Ernest's study, he repeated Sells' experiment for the student population at UCSB. From a file of all the freshmen admitted to UCSB in the fall of 1973, he took a random sample of 50 women and 50 men. Comparing the high school transcripts of these 100 freshmen, he found that 36 per cent of the men had a background of four years of high school mathematics, while only 16 per cent of the women had similar mathematics backgrounds. So his research confirmed Sells' findings concerning the lack of mathematics training among girls in high school.

Prior to 1974, the overwhelming evidence of research regarding sex differences in mathematical ability arrived at the conclusion that, though there may not have been such sex-related differences in grade school children, by the time learners reached junior high school, male superiority in mathematics was evident (11, p. 81). Since 1974, however, such conclusions regarding male superiority in mathematics are not as evident. Fennema felt that the effects of more controlled studies, more comparable populations, and more sophisticated analyses were having an effect.

By 1976 Fennema had arrived at some conclusions about sex-related differences in mathematics learning:

1. There are no sex-related differences evident in elementary school years.
2. After elementary school, differences do not always appear.
3. Starting at about 7th grade, if differences do appear, they tend to be in the males' favor.
4. There is some evidence that sex-related differences in mathematics learning ability in high school may not be as large in 1976 as they were in previous years.
5. Conclusions about male superiority have often been gathered from studies in which the number of mathematics courses taken was not controlled.

A 1978 report regarding sexual roles and mathematical expectations published by Rappaport concluded that although there is little difference in the ability of males and females to work with mathematics, the numbers of each sex that actually study mathematics shows great disparity (19, p. 195). Far more males than females enroll in mathematics courses, with the discrepancy increasing as the grade level increases. Recommendations were made that attitudinal changes need to be implemented in high schools, and students and parents at all points of selection in the high school years need to be made aware of the consequences of inadequate mathematical background.

Some significant findings came to light as a result of a questionnaire sent by Luchens in 1978 to all members of the Association for Women in Mathematics. In the 40 per cent response total were 350 females and 52 males, and the results showed that more women than men were discouraged by family, friends, teachers, and counselors in their decisions to become mathematicians. When asked if they were treated differently because of being female or male, over 80 per cent of the women and only 9 per cent of the men had encountered such difference in treatment because of their sex (17, p. 163). The respondents in this study were professional mathemati-

cians and professors of mathematics, who overcame discouragement and discrimination in order to complete their training. In the light of such an atmosphere, the researcher expressed no surprise that mathematics had come to be regarded as exclusively a male discipline.

After three years, preliminary results of a five-year project begun in 1975 in the Department of Mathematics and Statistics of Sheffield City Polytechnic School, Sheffield, England, were reported by Preece. One of the five areas initially tested among the 1250 students taking part in the study was whether the mathematical attitudes of boys and girls were different. After a year into the project, the questions were asked again, with strong sex differences appearing. Preece found that

the boys were no longer feeling that mathematics was easy but...they were prepared to settle down and take the work seriously. However, the girls' responses tended to convey an air of hopelessness; they did not expect to succeed, they felt no one else expected them to succeed. (18, p. 29)

Preece concluded that girls can rival boys in ability in the second year in a secondary school, but their self-defeatist attitude prevents it. The key to the whole problem seemed to be attitudes--how the girls felt about mathematics and how their parents, teachers, and employers felt about girls and mathematics.

Current Experiments in Combating Mathophobia

Mathophobia, an irrational and impeditive fear of mathematics, is a synonym for mathematics anxiety believed to have been introduced by Jerrold Zacharias of the Massachusetts Institute of Technology prior to 1970 (22, p. 59). Lazarus in 1974 indicated a thorough understanding of

the entire problem of mathematics anxiety at all levels, from elementary school through graduate school and also among adults. As a staff member of the Education Development Center in Newton, Massachusetts, he and his colleagues used innumerable personal interviews and case studies to define clearly a problem they felt was troubling a majority of humans (15, p. 17).

Among the conclusions they reached were the following: mathophobia could appear at any time during a person's school years; fear of mathematics was not the same as dyscalculia (inability to perform even the simplest computations); if mathophobia began early in the school years, the child who experienced it would later find almost all mathematics a mystery; there was a generally high incidence of mathophobia on college campuses; an obstacle to the prevention of mathophobia was the difficulty of early diagnosis; mathophobia was often transmitted unconsciously from parent to child and even from teacher to child. Lazarus felt strongly that

mathophobia is a highly communicable condition, to which the young are especially liable. (15, p. 22)

At the time (1974) this report was made not many studies had been done to determine who was fearful of mathematics and who was not. Since that time much research, especially in regard to women and mathematics, has been done, such as by Aiken in 1976, by Tobias in 1978, and by Fennema in 1978 in an attempt to answer some of the questions about mathematics anxiety. Tobias has been perhaps the most diligent in publishing her findings. The project she was instrumental in developing at Wesleyan University in Connecticut, that is, the opening of a diagnostic, testing, and counseling clinic called the Math Anxiety Clinic, has become well-known

nationally. At Wesleyan an active attempt was made to cure the symptoms of mathematics anxiety. Tobias later expanded her clinic into a commercial venture involving counseling the general public to help persons overcome fear of mathematics.

One-day conferences and seminars have been used extensively to alleviate mathematics anxiety, especially in college settings with high school participants. At the Lawrence Hall of Science, University of California, Berkeley, at Mills College, Oakland, California, and at St. Peter's College, Jersey City, New York, 7th through 12th grade girls were helped to improve their attitudes toward mathematics before severe anxiety had developed. Other short courses or workshops, such as at Mills College, at California State University, and at University of Missouri have been developed to help prepare women students for entry into the required advanced mathematics courses needed for careers in science and technology. As research continues into the extent and depth of mathematics anxiety, programs to combat the problem are likely to proliferate.

A Summary of the Review of the Literature

The literature indicated that since 1957 research has found mathematics anxiety existing in all ages of students, from elementary school through graduate school. Improved tests of mathematics anxiety such as the MARS test, have made the researcher's task easier. During the high school years girls' attitudes toward mathematics was found to provide fairly accurate predictions of their marks in mathematics.

Stereotyping of females almost from birth effectively convinces them that they are not as good at mathematics as boys are. One result of this

is that over half of all males entering college have a strong background in high school mathematics, whereas only about 10 per cent of entering women freshmen indicate such a background.

Teacher, parent, and counselor attitudes have tended to discourage females from studying more mathematics after sixth grade. Much of the sex-related differences in mathematical ability found in early studies was the result of studies in which the amount of previous mathematics study was not controlled. Some researchers have found little difference in the ability of males and females to actually work with mathematics. There is a wide difference in male and female attitudes toward mathematics, with most girls avoiding mathematics from junior high on.

Mathematics anxiety has been recognized as a significant problem by most researchers who have explored the topic. The ways to test for mathophobia have improved in recent times. Nation-wide programs have been developed to seek to alleviate the problem of mathematics anxiety.

CHAPTER III

METHOD OF PROCEDURE

The method of procedure in this study was to administer two measuring instruments to a population of 441 junior college students. One instrument measured the level of mathematics anxiety. The other was the means of collecting the variables of sex, age, background in mathematics, and grade in last completed mathematics course. The data was analyzed to discover whether any correlation existed between level of mathematics anxiety and each of the four variables; that is, between anxiety and sex, between anxiety and age, between anxiety and mathematics background, and between anxiety and last mathematics grade received.

The Data

The mathematics anxiety levels were determined according to the scores recorded by the subjects on the Mathematics Anxiety Rating Scale (MARS). The variables of sex, age, courses completed, and previous grade were obtained from a check list each subject completed just prior to taking the MARS test.

The Research Methodology

Based on consideration of the type of data and the four variables to be examined, the correlation method was chosen as being the most appropriate methodology.

The Survey Instruments

Mathematics anxiety was determined by each subject's score (range of

98 to 490) on the Mathematics Anxiety Rating Scale, or MARS, a copy of which is included in Appendix A. This scale, copyright in 1972 by Richard M. Suinn, was originally validated for reliability and internal consistency by Suinn on a large sample of University of Missouri students. The results led him to conclude that the instrument was highly reliable and that the test items were heavily dominated by a single, homogenous factor, which he termed mathematical anxiety. A later check for reliability was carried out by Suinn, Edie, Nicoletti, and Spinelli. (See Appendix B). The test-retest reliability coefficient was 0.78 after two weeks, significant at .001, which compares favorably to other scales used in clinical practice, such as the Taylor Manifest Anxiety Scale or the Fear Survey Schedule. Finally, the results of a validation study by Brush in 1978 supported the reliability and validity of this instrument (4, p. 489). Therefore, the MARS test was deemed suitable for testing the level of mathematics anxiety for this study, on the basis of its internal consistency and construct validity.

The check list used to obtain data for the variables to be tested was devised by the researcher from a consideration of the type of data required. A total of six types of information was requested from each area to be made to the best of their recollection. Two areas of information (full-time or part-time student and lapse of time since last mathematics class) were not considered in the present study. (The check list appears in Appendix C).

The check list was pretested on a small group in a pilot study. On the basis of this pre-test, each area of information was more clearly labeled, the listing of specific course names and specific grades was

added, and black lines were included beside each item for ease and speed in checking responses. A brief paragraph of information about the study was added to the top of the check list, since some subjects in the pilot test did not grasp the oral introductory remarks, and also written directions for each area were inserted.

The Population

The population from which information was gathered consisted of 441 freshmen and sophomores, including full and part-time students, enrolled for the Spring 1981 semester at Black Hawk College, a two-year comprehensive community college located in Moline, Illinois, a large midwestern city which is part of a multi-city area called the Quad-Cities. They ranged in age from 17 to 45 and they were all enrolled in one of the mathematics classes at the college which are considered precalculus level or are unrelated to calculus in content. The participants, when asked to cooperate in the study, were willing to do so.

Form of the Data

The MARS test uses a specific numerical score to indicate the level of mathematics anxiety for each subject. The check list (shown in Appendix C) was coded numerically in the following manner. (See Appendix D). Sex was coded as 1 for male and 2 for female. Part-time was coded as 1 and full-time as 2. Age was already in numerical form. Each item of the list of previous mathematics classes completed was assigned a code number, from 1 to 15, according to the level of mathematical ability required to complete the course. The number of years since the last mathematics class was already in numerical form. The grades of A, B, C, and D, F, or W were coded as 1, 2, 3, or 4.

For each subject a total of seven coded numbers was obtained. For example, a subject might have received the following coded values:

315 2 1 23 2 7 3

The 315 would be the MARS score. The 2 would mean female, the 1 would indicate a full-time student, 23 years old. The next 2 would indicate completion of Algebra I in high school with no other mathematics background. The next code, a 7, would indicate that seven years had elapsed since the Algebra I course had been completed, and the 3 would indicate a grade of C for the course.

Thus for each of the 441 subjects a set of seven items of information was obtained, coded in the preceding manner to permit facilitation of analysis of the data by computerized techniques.

CHAPTER IV

ANALYSIS OF THE DATA

Hypothesis 1

There is no significant difference between the level of math anxiety experienced by males and the level of math anxiety experienced by females, at the .05 level, as tested by use of the MARS Test.

It was determined that a two-sample T-test for the difference in means of anxiety scores indicated by females' and males' scores of mathematics anxiety would be used. An F-test for the differences in the variances between the two samples was also conducted. Analysis of the data is shown below.

Report of Anxiety Scores by Sex

	<u>Number</u>	<u>Average of Scores</u>	<u>Sum</u>	<u>Sum of Squares</u>	<u>Variance</u>
Men	215	189.409	40,723	8,248,177	2499.3551
Women	<u>226</u>	204.310	46,174	10,109,198	3001.7794
Total	441				

$$F = 1.2010$$

$$t = -2.9788$$

At $\alpha = .05$, F is critical at 1.26. The observed value of 1.20 for F is not sufficient to indicate a significant difference in variances.

At $\alpha = .05$, t is critical at approximately 1.96. The observed value of $t = -2.9788$ is sufficient to indicate a significant difference in the means of anxiety scores by sex. The probability of observing a

t-value as large as 2.9788 by chance is less than 15 of 10,000 ($p < .0015$).

Therefore, the null hypothesis of no difference in levels of anxiety between males and females is rejected.

Hypothesis 2

There is no significant difference, at the .05 level, among the levels of math anxiety experienced by persons of different ages.

A regression model of anxiety as a function of age was selected as the best method for determining if correlation between mathematical anxiety and age existed. Results are indicated below:

Anxiety Scores Regressed on Age

	<u>Number</u>	<u>Sum</u>	<u>Sum of Squares</u>
Age	441	9,709	229,825
Scores	441	86,897	18,357,357
Mean for ages		22.02	
Mean for scores		197.05	
Regression:	Scores = $207.530 + 0.476 \text{ age}$		
Coefficient of correlation is		-0.0543	

The coefficient of correlation of 0.0543 is so near zero that data do not conform well to a line of regression and indicates that age alone accounts for extremely little of the variability in anxiety scores. Since the coefficient of correlation indicates that correlation between mathematical anxiety and age is not statistically significant, the null hypothesis of no difference is retained.

Hypothesis 3

There is no significant difference, at the .05 level, between the levels of mathematics anxiety experienced by persons with different backgrounds of mathematical experience (shown by the highest level of mathematics course previously completed).

For the third hypothesis an analysis of variance model on the highest level of mathematics course completed was used. Each course from general mathematics through calculus was coded and the mean within each group for each code was computed, along with the sum of the squares within each grouping. Total data are shown below:

Anxiety Based on Course

<u>Code</u>	<u>Name of Course</u>	<u>Number</u>	<u>Mean</u>	<u>Sum of Squares Within</u>
1	General Mathematics	45	230.533	177,789.220
2	Algebra I	65	194.585	172,501.780
3	Geometry	69	191.507	182,159.250
4	Algebra II	46	203.804	151,957.230
5	Trigonometry	21	186.190	70,667.242
6	Advanced Algebra	14	175.929	15,240.930
7	Algebra I (081)	21	219.762	33,995.805
8	Math 100	30	208.333	96,594.656
9	Intermediate Algebra	56	190.179	66,706.219
10	College Algebra	38	179.737	67,949.375
11	Math 131	16	177.500	34,722.000
12	Math 228	3	219.000	8,358.000
13	Trigonometry	2	192.500	1,404.500
14	Precalculus	9	210.000	24,288.000
15	Calculus	6	<u>132.667</u>	<u>3,935.334</u>
Total			197.045	1,234,725.300

Anxiety Scores Within Classes Completed

<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>MS</u>	<u>F</u>
Among	14	126,456	9032.540	3.4720
Within	<u>426</u>	<u>1,108,270</u>	2601.572	
Total	440	1,234,726		

At $\alpha = .05$ and 14, 426 degrees of freedom, F is critical at 1.49. The observed value of F of 3.4720 indicates a difference that is significant. The null hypothesis of no difference between levels of mathematical anxiety for different mathematical backgrounds is rejected.

Hypothesis 4

There is no significant difference, at the .05 level, between level of mathematics anxiety experienced by persons receiving different grades in their last completed math courses.

For the fourth hypothesis, a chi-square model was used. Summary of data is shown below:

Chi Square Model

								<u>Totals</u>	<u>Grade</u>
14	19	20	10	13	6	2	4	88	A
8	17	37	29	31	11	16	13	162	B
4	15	22	18	22	25	14	20	140	C
<u>2</u>	<u>3</u>	<u>8</u>	<u>7</u>	<u>10</u>	<u>10</u>	<u>5</u>	<u>6</u>	<u>51</u>	D-F
28	54	87	64	76	52	37	43	441	

54.21327

At $\alpha = .05$, chi-squared is critical at 32.671. The observed value of chi-squared of 54.213 is significant, indicating the grade received in the last completed mathematics class and anxiety scores are not independent.

Therefore, the null hypothesis of no difference in mathematics anxiety scores for different grades in the last completed mathematics class is rejected.

CHAPTER V

SUMMARY AND CONCLUSIONS

The first hypothesis having been rejected, it must be concluded that there is a significant difference between the level of mathematics anxiety experienced by males and the level experienced by females. The study was carried out with 215 males, the mean of whose scores was 189.4. For the 226 females in the study, the mean of scores was 204.3. For this particular study, the mean of anxiety scores for females was significantly higher than that of the males. This result confirms research results obtained in the past comparing mathematics anxiety levels of females and males. Further research needs to be done, confirming these findings and seeking possible causes of the difference.

The second null hypothesis was retained by the study. Age was shown to be unrelated to the level of mathematics anxiety exhibited. It is concluded that the age of a person would not be an accurate predictor of the level of mathematics anxiety of the person.

The third null hypothesis was rejected in the study. Therefore, the mathematical background of the participants and the level of mathematical anxiety felt by each were related. From this one study, no attempt can be made to generalize just what that relationship is. However, it might be of interest to note that the 45 subjects who had completed only a general mathematics course as their highest level showed a mean of 230.53 in mathematics anxiety level, while the six subjects who had completed Calculus I or higher showed a mean of scores of only 132. These two

means were the highest and lowest respectively of all the means for the 15 levels of courses completed.

The fourth null hypothesis was also rejected, indicating that there was correlation between the level of mathematics anxiety and the grade received in the last completed mathematics course. In this study, 88 subjects had received A in the last completed mathematics class, 162 had received B, 140 had received C, and 51 had received D, F, or W. The mean for all the 441 grades was 2.431 or approximately B-, with a 2 representing a B, and a 3 representing a C. For regression, score was equal to $171 + 10.665 (\text{grade received})$. The correlation has been established between the previous grade received and level of mathematics anxiety, but further research is needed before any conclusions can be drawn concerning predictor factors in the area of mathematical anxiety.

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APPENDIX A

NAME _____

Total Score _____

MATHEMATICS ANXIETY RATING SCALE (MARS)

The items in the questionnaire refer to things and experiences that may cause fear or apprehension. For each item, place a check (✓) in the box under the column that describes how much you are frightened by it nowadays. Work quickly but be sure to consider each item individually.

	Not at all	A little	A fair amount	Much	Very much
1. Determining the amount of change you should get back from a purchase involving several items.	☐	☐	☐	☐	☐
2. Having someone watch you as you total up a column of figures.	☐	☐	☐	☐	☐
3. Having someone watch you as you divide a five digit number by a two digit number.	☐	☐	☐	☐	☐
4. Being asked to add up $976 + 777$ in your head.	☐	☐	☐	☐	☐
5. Dividing a five digit number by a two digit number in private with pencil and paper.	☐	☐	☐	☐	☐
6. Calculating a simple percentage, e. g., the sales tax on a purchase.	☐	☐	☐	☐	☐
7. Listening to a salesman show you how you would save money by buying his higher priced product because it reduces long term expenses.	☐	☐	☐	☐	☐
8. Listening to a person explain how he figured out your share of expenses on a trip, including meals, transportation, housing, etc.	☐	☐	☐	☐	☐
9. Having to figure out how much it will cost to buy a product on credit (figuring in the interest rates).	☐	☐	☐	☐	☐
10. Totaling up a dinner bill that you think overcharged you.	☐	☐	☐	☐	☐
11. Telling the cashier that you think the dinner bill was incorrect and watching the cashier total up the bill.	☐	☐	☐	☐	☐

TOTAL _____

	Not at all	A little	A fair amount	Much	Very much
12. Being treasurer for a club.	☐	☐	☐	☐	☐
13. Totaling up the dues received and the expenses of a club you belong to.	☐	☐	☐	☐	☐
14. Adding up $976 + 777$ on paper.	☐	☐	☐	☐	☐
15. Doing a word problem in algebra.	☐	☐	☐	☐	☐
16. Solving a problem such as: If $x = 11$, and $y = 3$, then the results of x/y is equal to _____?	☐	☐	☐	☐	☐
17. Solving the problem such as: If $x = 12$, and $y = 4$, then the ratio of x to y is equal to _____?	☐	☐	☐	☐	☐
18. Determining the grade point average for your last term.	☐	☐	☐	☐	☐
19. Reading an article on the basketball team, showing what percentage of free throws each player made, the percentage of field goals made, the total number attempted, etc.	☐	☐	☐	☐	☐
20. Reading an historical novel with many dates in it.	☐	☐	☐	☐	☐
21. Counting the number of pages left in a novel you are engrossed in.	☐	☐	☐	☐	☐
22. Guessing at the number of people attending a dance you're at.	☐	☐	☐	☐	☐
23. Buying a math textbook.	☐	☐	☐	☐	☐
24. Watching someone work with a slide rule.	☐	☐	☐	☐	☐
25. Watching a teacher work an algebraic equation on the blackboard.	☐	☐	☐	☐	☐
26. Signing up for a math course.	☐	☐	☐	☐	☐
27. Listening to another student explain a math formula.	☐	☐	☐	☐	☐
28. Walking into a math class.	☐	☐	☐	☐	☐

TOTAL

	Not at all	A little	A fair amount	Very much
29. Having to compute the miles/gallon on your car.	☐	☐	☐	☐
30. Watching someone work with a calculator.	☐	☐	☐	☐
31. Looking through the pages of a math text.	☐	☐	☐	☐
32. Working on an income tax form.	☐	☐	☐	☐
33. Reading your W-2 form (or other statement showing your annual earning and taxes).	☐	☐	☐	☐
34. Studying for a math test.	☐	☐	☐	☐
35. Starting a new chapter in a math book.	☐	☐	☐	☐
36. Walking on campus and thinking about a math course.	☐	☐	☐	☐
37. Meeting your math teacher while walking on campus.	☐	☐	☐	☐
38. Reading the word "Statistics."	☐	☐	☐	☐
39. Sitting in a math class and waiting for the instructor to arrive.	☐	☐	☐	☐
40. Solving a square root problem.	☐	☐	☐	☐
41. Signing up for a course in Statistics.	☐	☐	☐	☐
42. Checking over your monthly bank statement.	☐	☐	☐	☐
43. Taking the math section of a college entrance exam.	☐	☐	☐	☐
44. Having someone explain bank interest rates as you decide on a savings account.	☐	☐	☐	☐
45. Raising your hand in a math class to ask a question.	☐	☐	☐	☐
46. Reading and interpreting graphs or charts.	☐	☐	☐	☐

TOTAL

40

	Not at all	A little	A fair amount	Much	Very much
47. Reading a cash register receipt after your purchase.	☐	☐	☐	☐	☐
48. Figuring the sales tax on a purchase that costs more than \$1.00.	☐	☐	☐	☐	☐
49. Having a person illustrate to you the best way to divide your money into a savings and a checking account.	☐	☐	☐	☐	☐
50. Figuring out which of two summer job offers is the most lucrative: where one involves a lower salary, room and board, and travel, while the other one involves a higher salary but no other benefits.	☐	☐	☐	☐	☐
51. Reading a formula in chemistry.	☐	☐	☐	☐	☐
52. Hearing a lecture in a social science class where the instructor is commenting on some figures, e. g., the percentage of each socio-economic group who voted Republican.	☐	☐	☐	☐	☐
53. Taking an examination (quiz) in a math course.	☐	☐	☐	☐	☐
54. Taking an examination (final) in a math course.	☐	☐	☐	☐	☐
55. Hearing two of your friends exchanging opinions on the best way to calculate the cost of a product.	☐	☐	☐	☐	☐
56. Having someone ask you to recheck his figures in a simple calculation, such as division, or addition.	☐	☐	☐	☐	☐
57. Being asked by a friend to answer the question: how long will it take to get to Denver if I drive at 30 miles per hour?	☐	☐	☐	☐	☐
58. Studying for a driver's license test and memorizing the figures involved, such as the distances it takes to stop a car going at differing speeds.	☐	☐	☐	☐	☐
59. Hearing friends make bets on a game as they quote the odds.	☐	☐	☐	☐	☐
60. Playing cards where numbers are involved, e. g., bridge or poker.	☐	☐	☐	☐	☐

TOTAL

11

	Not at all	A little	A fair amount	Much	Very much
61. Hearing a friend try to teach you a math procedure and finding that you cannot understand what he is telling you.	☐	☐	☐	☐	☐
62. Scheduling my daily routine to allocate set times for classes, for study time, for meals, for recreation, etc.	☐	☐	☐	☐	☐
63. Juggling class times around at registration to determine the best schedule.	☐	☐	☐	☐	☐
64. Deciding which courses to take in order to come out with the proper number of credit hours for full time enrollment.	☐	☐	☐	☐	☐
65. Working a concrete, everyday application of mathematics that has meaning to me, e. g., figuring out how much I can spend on recreational purposes after paying other bills.	☐	☐	☐	☐	☐
66. Working on an abstract mathematical problem, such as: "If x = outstanding bills, and y = total income, calculate how much you have left for recreational expenditures."	☐	☐	☐	☐	☐
67. Being given a set of numerical problems involving addition to solve on paper.	☐	☐	☐	☐	☐
68. Being given a set of subtraction problems to solve.	☐	☐	☐	☐	☐
69. Being given a set of multiplication problems to solve.	☐	☐	☐	☐	☐
70. Being given a set of division problems to solve.	☐	☐	☐	☐	☐
71. Picking up the math text book to begin working on a homework assignment.	☐	☐	☐	☐	☐
72. Being given a homework assignment of many difficult problems which is due the next class meeting.	☐	☐	☐	☐	☐
73. Thinking about an upcoming math test one week before.	☐	☐	☐	☐	☐
74. Thinking about an upcoming math test one day before.	☐	☐	☐	☐	☐

TOTAL

42

	Not at all	A little	A fair amount	Much	Very much
75. Thinking about an upcoming math test one hour before.	☐	☐	☐	☐	☐
76. Thinking about an upcoming math test five minutes before.	☐	☐	☐	☐	☐
77. Talking to someone in your class who does well about a problem and not being able to understand what he is explaining.	☐	☐	☐	☐	☐
78. Waiting to get a math test returned in which you expected to do well.	☐	☐	☐	☐	☐
79. Waiting to get a math test returned in which you expected to do poorly.	☐	☐	☐	☐	☐
80. Walking to math class.	☐	☐	☐	☐	☐
81. Realizing that you have to take a certain number of math classes to fulfill the requirements in your major.	☐	☐	☐	☐	☐
82. Picking up a math textbook to begin a difficult reading assignment.	☐	☐	☐	☐	☐
83. Being called upon to recite in a math class when you are prepared.	☐	☐	☐	☐	☐
84. Not knowing the formula needed to solve a particular problem.	☐	☐	☐	☐	☐
85. Receiving your final math grade in the mail.	☐	☐	☐	☐	☐
86. Opening a math or stat book and seeing a page full of problems.	☐	☐	☐	☐	☐
87. Being responsible for collecting dues for an organization and keeping track of the amount.	☐	☐	☐	☐	☐
88. Getting ready to study for a math test.	☐	☐	☐	☐	☐
89. Listening to a lecture in a math class.	☐	☐	☐	☐	☐
90. Figuring out your monthly budget.	☐	☐	☐	☐	☐

TOTAL

	Not at all	A little	A fair amount	Much	Very much
91. Being given a "pop" quiz in a math class.	☐	☐	☐	☐	☐
92. Seeing a computer printout.	☐	☐	☐	☐	☐
93. Having to use the tables in the back of a math book.	☐	☐	☐	☐	☐
94. Being told how to interpret probability statements.	☐	☐	☐	☐	☐
95. Asking your math instructor to help you with a problem that you don't understand.	☐	☐	☐	☐	☐
96. Being asked to explain how you arrived at a particular solution for a problem.	☐	☐	☐	☐	☐
97. Tallying up the results of a survey or poll.	☐	☐	☐	☐	☐
98. Acting as secretary, keeping track of the number of people signing up for an event.	☐	☐	☐	☐	☐

TOTAL

Total Score

=====

APPENDIX B

TABLE 1
Means, SD's and Reliability Coefficients
for the MARS in Three Samples

Sample	Mean		Reliability*
	1st Testing	2nd Testing	
Colorado State University (N=119)	187.3 (SD=55.5)	179.9 (SD=59.9)	0.78 (after 2 wks)
University of Missouri Sample A (N=35)	235.1 (SD=51.3)	232.9 (SD=56.5)	0.85 (after 7 wks)
University of Missouri Sample B (N=397)	215.4 (SD=65.3)		0.97

*Test-retest internal consistency.

TABLE 2
MARS Score Percentile Equivalents*

Percentile	Score
10%	140
20%	160
25%	165
35%	185
50%	215
60%	230
75%	255
80%	265
95%	315

*Based on University of Missouri Sample (N=397)

APPENDIX C

You are taking part in a study to find out if various levels of mathematics anxiety go along with other data in people's lives. Your help is very much appreciated.

CHECK LIST

Please check appropriate answers about yourself below:

Sex: _____ M
 _____ F

_____ Part-time Student
 (11 hrs. or less)
 _____ Full-time Student
 (12 hours or more)

Age: _____

What mathematics course are you enrolled in this semester? _____

What mathematics classes have you completed?

In High School:

In College:

_____ General Math.

_____ Alg. I

_____ Alg. I

_____ Intermed. Alg.

_____ Geometry

_____ College Alg. _____

_____ Alg. II

_____ Trig. _____

_____ Trig.

_____ Precalculus _____

_____ Advanced (college)
 Alg.

_____ Math 100 _____

_____ Other
 (please specify)

How long ago did you complete your last math study?

_____ last semester

_____ last year

_____ two years ago

or _____ years ago (please specify).

What grade did you receive in your last math class?

_____ A

_____ D

_____ B

_____ F

_____ C

_____ W

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 96 Powell Library Building
 University of California
 Los Angeles, California 90024

APPENDIX D

You are taking part in a study to find out if various levels of mathematics anxiety go along with other data in people's lives. Your help is very much appreciated.

CHECK LIST

Please check appropriate answers about yourself below.

Sex: 1 M
2 F

1 Part-time Student
(11 hrs. or less)

Age: _____

2 Full-time Student
(12 hours or more)

What mathematics course are you enrolled in this semester? _____

What mathematics classes have you completed?

In High School:

In College:

1 General Math.

7 Alg. I

2 Alg. I

9 Intermed. Alg.

3 Geometry

10 College Alg.

11 MATH 131

4 Alg. II

13 Trig.

12 MATH 228

5 Trig.

14 Precalculus

6 Advanced (college)
Alg.

8 Math 100

15 CALCULUS other
(please specify)

How long ago did you complete your last math study?

_____ last semester

_____ last year

_____ two years ago

or _____ years ago (please specify).

What grade did you receive in your last math class?

1 A
2 B
3 C
4 (D
 F
 W